CLERMONT SOLAR FARM

GLARE IMPACT ASSESSMENT REPORT

Prepared For

Epuron

Final Issue: February 2017

Prepared By Environmental Ethos on behalf of
Epuron

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CONTENTS

1. INTRODUCTION

This report has been prepared by Environmental Ethos on behalf of the proponent Epuron to assess the potential glare impact of the Clermont Solar Farm (the Project). The Project comprises of the installation and operation of a 150 MW solar farm that will utilise photovoltaic (PV) modules to generate electricity.

The Project site is freehold rural property at Alpha Street Bypass Road, described as Lot 6 SP159756, Lot 220 CLM102 and Lot 153 CLM230 within the Issac Regional Council area. The total footprint of the proposed development will cover an area of approximately 310 hectares (ha) and will be completed in up to two (2) stages.

1.1. Location

The Project site is located approximately 6 kilometres west of the town of Clermont, within the Central Queensland region, *refer Figure 1.* The study area is bounded by Alpha Street Bypass Road to the north and rural properties to the east, west, and south. The connecting substation is located to the south east of the Project site, adjoining Clermont Rubyvale Road. Connection to the substation is required as part of the Project. The site is currently used for broad acre grazing, which is the primary land use within the Project surrounds.

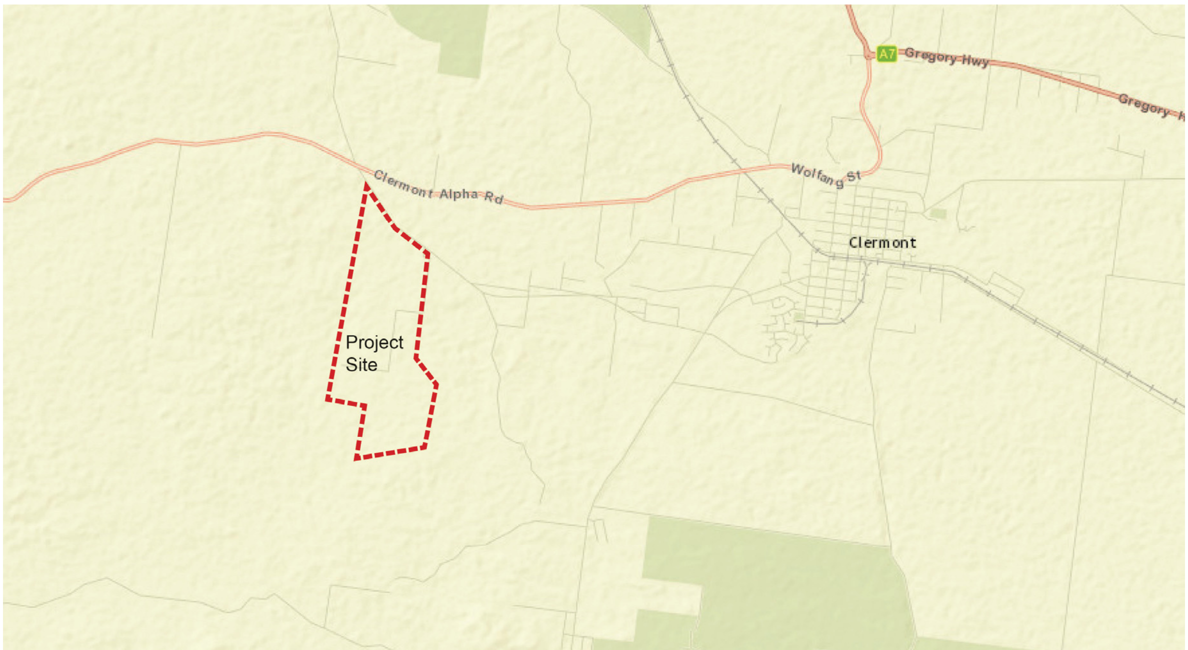


Figure 1. Location Plan

The Project site is slightly undulating land with a gentle slope from south to north. Native vegetation on the site has been predominantly cleared for grazing and there is some recent regrowth occurring across the site. An existing track (Lindley Road) passes through the centre of the site connecting the adjoining property to the west with Alpha Bypass Road. Whilst access will be retained along this track, this assessment did not include the track as it is within the Project site. The site has few landscape constraints to the development of a solar farm.

2. SCOPE OF THE ASSESSMENT

The scope of this Glare Assessment includes the following:

- Description of the methodology used to undertake the study;
- Description of the elements of the Project with the potential to influence glare including size, height, and angle of PV modules, and type and operation of tracking systems;
- Identification of the viewshed and potential visibility of the Project;
- Desktop mapping of potential glare at the location of sensitive receptors within the viewshed, based on Solar Glare Hazard Analysis and viewshed analysis,
- Assessment of the baseline conditions; and
- Assessment of the potential risk of glare on sensitive receptors during operation of the Project.

3. METHODOLOGY

3.1. Glare Assessment Parameters

Glare assessment modelling for solar farms is based on the following factors:

- the tilt, orientation, and optical properties of the PV modules in the solar array;
- sun position over time, taking into account geographic location;
- the location of sensitive receptors (viewers); and
- Screening potential of surrounding topography and vegetation.

3.2. Glare Intensity Categories

Glare refers to the human experience of reflected light. The potential hazard from solar glare is a function of retinal irradiance (power of electromagnetic radiation per unit area produced by the sun) and the subtended angle (size and distance) of the glare source. [1]

Glare can be broadly classified into three categories: low potential for after-image, potential for after-image, and potential for permanent eye damage, *Figure 2* illustrates the glare intensity categories.

[1] HO, C.K., C.M. Ghanbari, and R.B. Diver, 2011, Methodology to Assess Potential Glint and Glare hazards from Concentrated Solar Power Plants

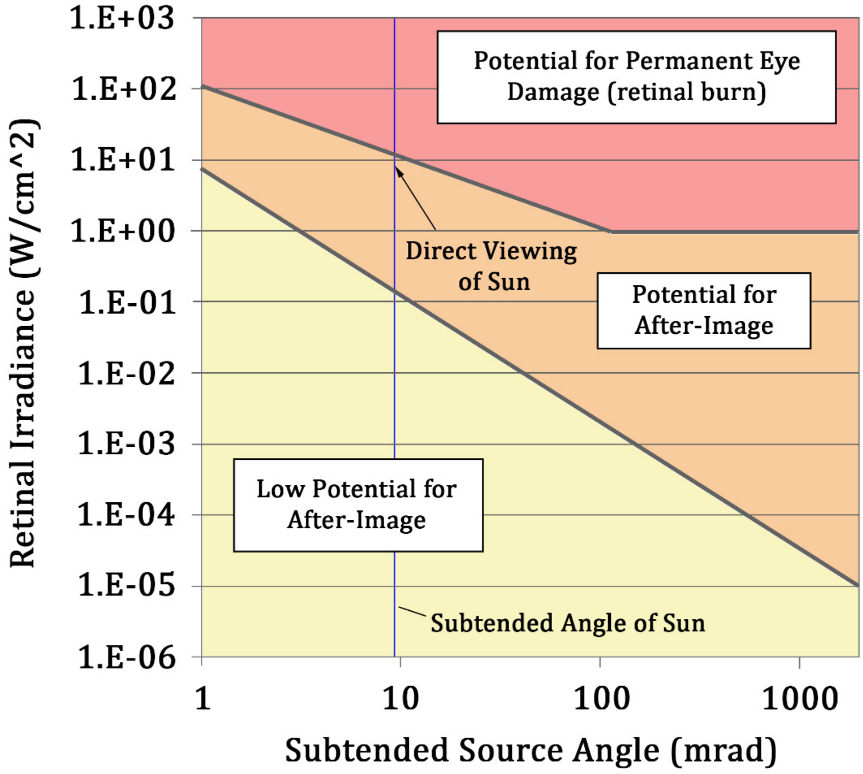


Figure 2. Ocular impacts and Hazard Ranges[2]

The amount of light reflected from a PV module depends on the amount of sunlight hitting the surface, as well as the surface reflectivity. The amount of sunlight interacting with the PV module will vary based on geographic location, time of year, cloud cover, and PV module orientation. 1000W/m^2 is generally used in most counties as an estimate of the solar energy interacting with a PV module when no other information is available. This study modelled scenarios using 2000 W/m^2 in order to cover potentially higher solar energy levels in Australia as compared to other parts of the world. Flash blindness for a period of 4-12 seconds (i.e. time to recovery of vision) occurs when 7-11 W/m^2 (or 650-1,100 lumens/m^2) reaches the eye[3].

3.3. Reflection and Angle of Incidence

PV modules are designed to maximise the absorption of solar energy and therefore minimise the extent of solar energy reflected. PV modules have low levels of reflectivity between 0.03 and 0.20 depending on the specific materials, anti-reflective coatings, and angle of incidence.[4]

The higher reflectivity values of 0.20, that is 20% of incident light being reflected, can occur when the angle of incidence is greater than 50^o. *Figure 3 and 4* show the relationship between increased angles of incidence and increased levels of reflected light. Where the angle of incidence remains below 50° the amount of reflected light remains below 10%. The angle of incident is particularly

[2] Source: Solar Glare Hazard Analysis Tool (SGHAT) Presentation (2013) https://share.sandia.gov/phlux/static/references/glint-glare/SGHAT_Ho.pdf
[3] Sandia National Laboratory, SGHAT Technical Manual
[4] *Ho, C. 2013 Relieving a Glare Problem*

relevant to specular reflection (light reflection from a smooth surface). Diffuse reflection (light reflection from a rough surface) may also occur in PV modules, however this is typically a result of dust or similar materials building up on the PV module surface, which would potentially reduce the reflection.

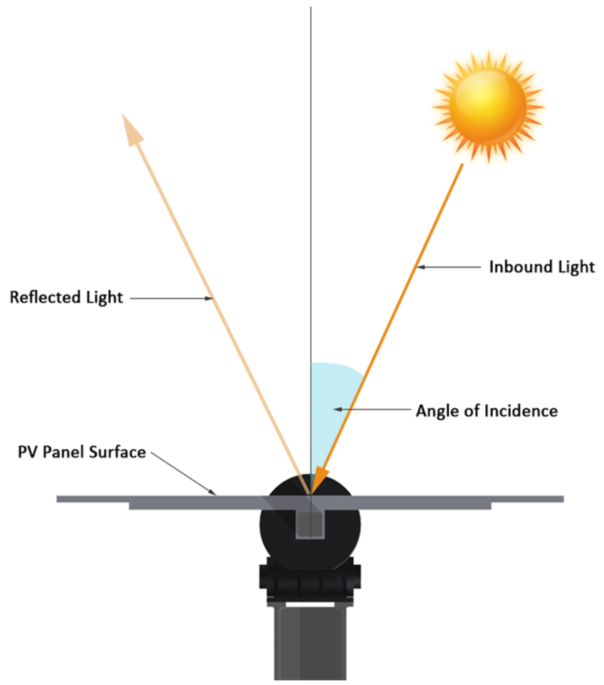


Figure 3. Angle of Incidence Relative to PV Panel Surface

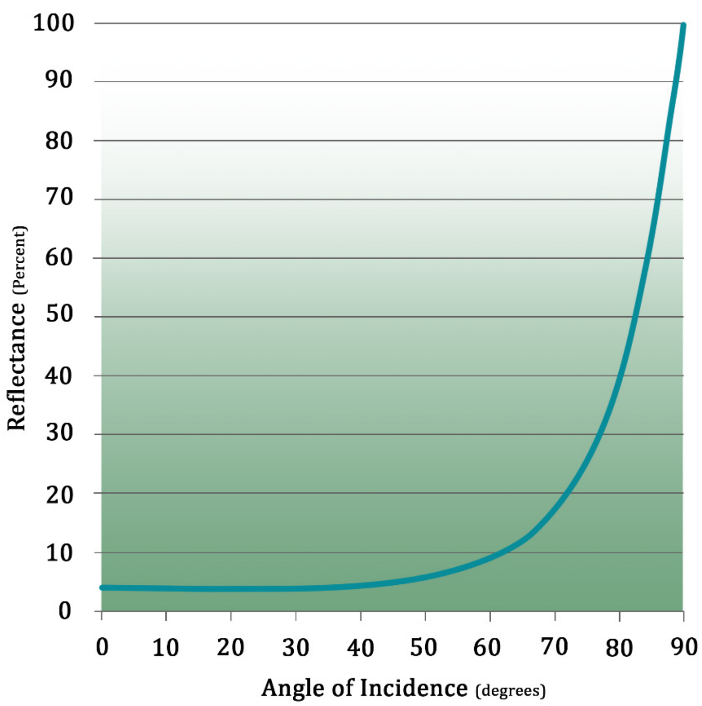


Figure 4. Angles of Incidence and Increased Levels of Reflected Light (Glass (n-1.5))

The sun changes its east-west orientation throughout the day, and the sun's north-south position in the sky changes throughout the year. The sun reaches its highest position at noon on the Summer

Solstice (21 December in the Southern Hemisphere) and its lowest position at sunrise and sunset on the Winter Solstice (21 June in the Southern Hemisphere).

In a fixed PV solar array, the angle of incidence varies as the sun moves across the sky, that is, the angle of incidence are at their lowest around noon where the sun is directly overhead, and increase in the early mornings and late evenings as the incidence angles increase. If the PV array is mounted on a tracking system, this variation is reduced because the panel is rotated to remain perpendicular to the sun. Therefore a PV modular array using a tracking system has less potential to cause glare whilst it tracks the sun. *Figure 5* illustrates a PV module mounted horizontal single axis tracking system following the east to west path of the sun.

A single axis tracking system has a fixed maximum angle of rotation, once the tracking mechanism reaches this maximum angle, the PV modules position relative to the sun becomes fixed and therefore the angle of incidence increases and the potential for glare increases. Some tracking systems utilise 'backtracking' to avoid PV modules over shadowing each other. During the backtracking procedure (early morning and late afternoon) the tracking system begins to rotate away from the sun to reduce shadow casting to adjoining PV panels. During the backtracking phase, higher angles of incidence will occur in comparison to the tracking phase, and this may increase the potential for glare.

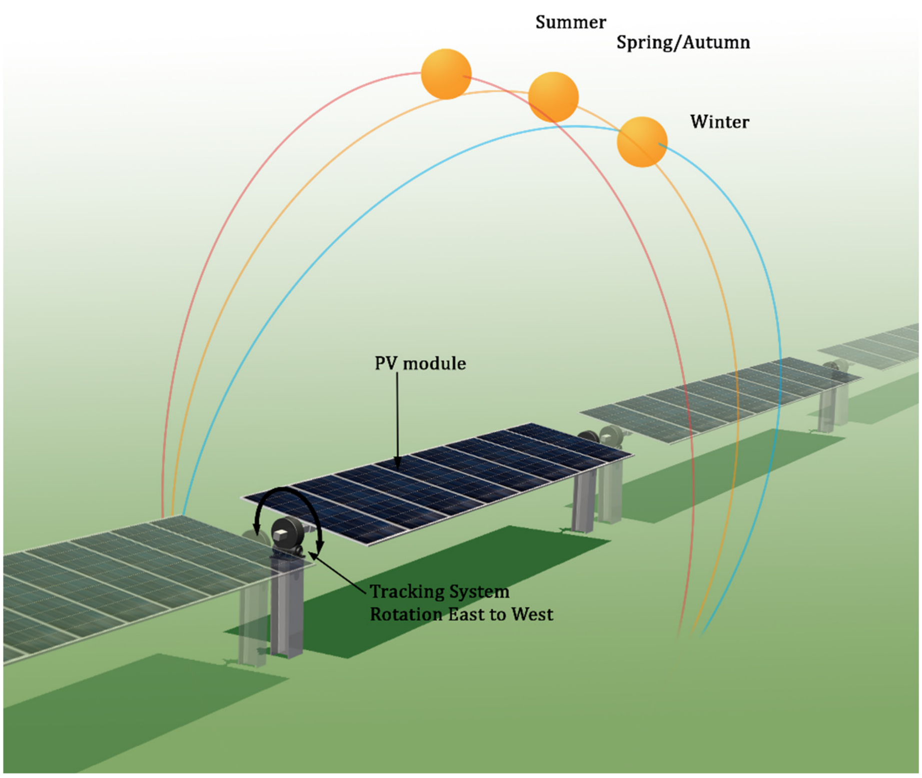


Figure 5. Diagrammatic illustration of sun position relative to PV module mounted on a horizontal single axis tracking system.

3.4. View shed Analysis

The viewshed analysis identifies the limit of visibility of the solar farm based on an assessment of topography and vegetation. A basic 3D model of the solar farm is placed into a Digital Terrain Model (DTM), the DTM used in this study is based on a contour interval of 5 metres. The location of sensitive receptors (dwellings, roads, etc) are located relative to the location of the solar farm and view lines between the two assessed taken into consideration intervening topography. The outcome of the modelling is then assessed in the field and the screening potential of existing vegetation taken into consideration. The result is a map showing the extent of the viewshed, potential visibility of the solar farm and therefore the potential for glare. The viewshed analysis is used in conjunction with solar hazard assessment software to assess the potential for solar glare hazard.

3.5. Solar Glare Hazard Analysis

This assessment has utilised the Solar Glare Hazard Analysis Tool (SGHAT 2.0) developed by Sandi National Laboratory[5] to assess potential glare utilising latitude and longitudinal coordinates, elevation, sun position, and vector calculations. The PV module orientation, reflectance environment and ocular factors are also considered by the software. If potential glare is identified by the model, the tool calculates the retinal irradiance and subtended angle (size/distance) of the glare source to predict potential ocular hazards according to the glare intensity categories (refer *Section 3.2*).

The sun position algorithm used by SGHAT calculates the sun position in two forms: first as a unit vector extending from the Cartesian origin toward the sun, and second as azimuthal and altitudinal angles. The algorithm enables determination of the sun position at one (1) minute intervals throughout the year.

The SGHAT is a high level tool and does not take into consideration the following factors:

- Backtracking or the effect of shading in relation to the PV array tracking system
- Gaps between PV modules
- Atmospheric conditions
- Topography and vegetation between the solar panels and the viewer (sensitive receptor)

SGHAT has been used extensively in the United States to assess the potential impact of solar arrays located in close proximity to airports. The US Federal Aviation Administration requires the use of SGHAT to demonstrated compliance with the safety requirements of all proposed solar energy systems located at federally obligated airports. Used in conjunction with a viewshed analysis, the two tools represent a conservative assessment.

3.6. Baseline Conditions

The baseline is a statement of the characteristics which currently exist in the Project area. The baseline glare condition assessment takes into consideration the following:

- Characteristics of the environment that may affect the potential for glare;

[5] https://share.sandia.gov/phlux/static/references/glint-glare/SGHAT_Technical_Reference-v5.pdf

- Land use and human modifications to the landscape such as roads, buildings and existing infrastructure which may influence glare and sensitivity to glare.

3.7. Risk Assessment Approach

Once the potential for glare has been identified through the viewshed analysis and SGHAT, the potential magnitude of the glare hazard is considered relative to background conditions. A risk assessment approach is then used to identify the potential significance of the risk based on the magnitude of the glare hazard generated and the sensitivity of the receptors (viewers).

4. PROJECT DESCRIPTION

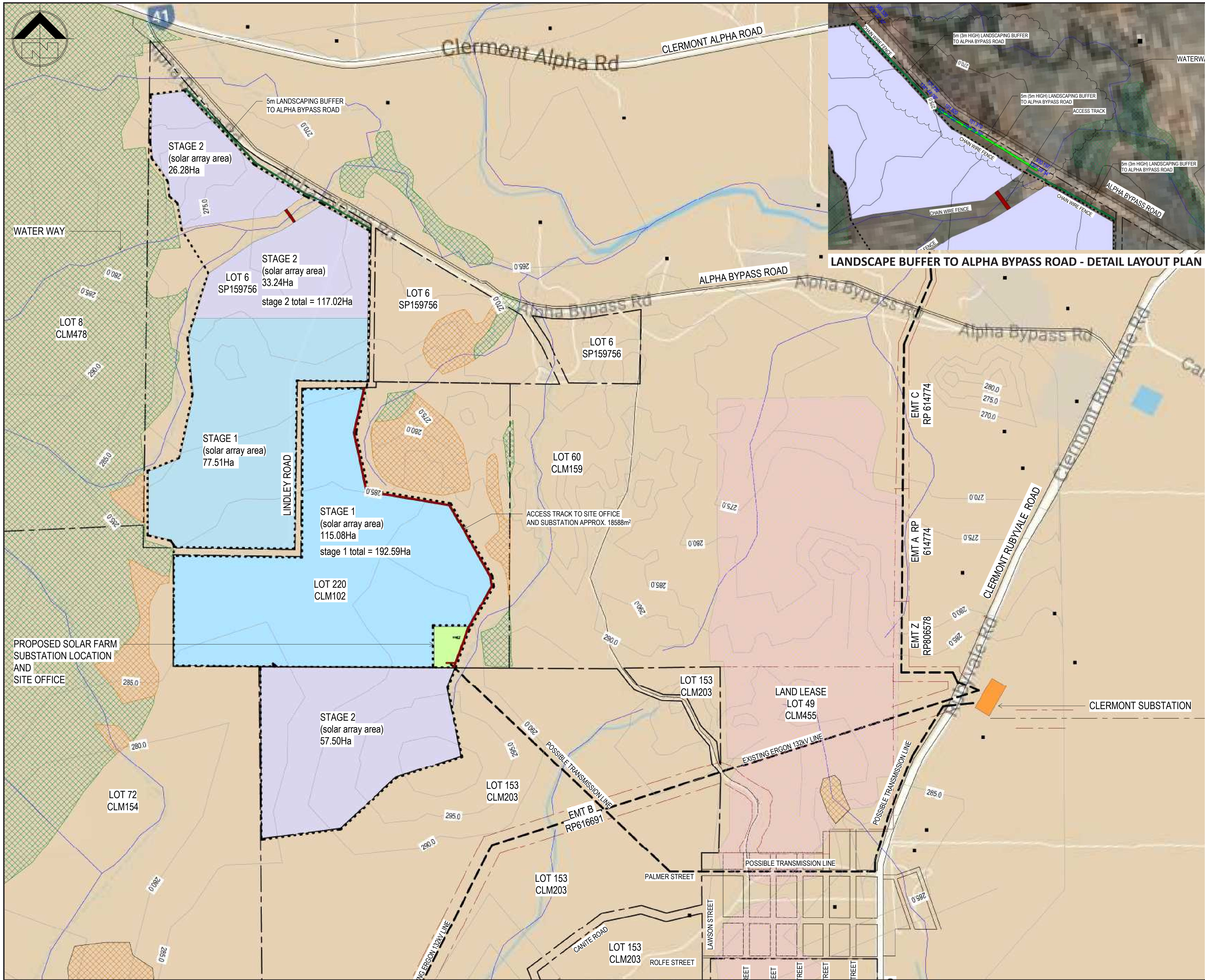
The general layout of the solar farm is as show in *Figure 6.* The main elements of the Solar Farm with the potential to influence glare are the tilt, orientation, and optical properties of the PV modules in the solar array, and the type and rotational capabilities of the tracking system. The study assessed two types of tracking systems, a horizontal single axis tracking system, and a fixed tilt system. Whilst specific products are yet to be determined for the Project, the general technical properties of the main elements influencing glare are described below.

4.1. PV modules

The specific type of PV module utilised in the Project has yet to be determined and will not be finalised until around the time of construction commencing. However PV modules are generally consistent in form and function, and an illustrative example is provided below. As a general principle, PV modules are designed to absorb solar radiation, not reflect it, and the solar radiation is converted into electricity.

Each PV panel comprises of approximately 72 polycrystalline silicon solar cell overlayed by a 3.2 to 4.0 mm tempered glass front and held in an anodised aluminium alloy frame. The approximate dimensions for a typical solar array are 7 metres x 2 metres, being made up of approximately 7 individual solar panels of approximately 2 metres x 1 metre. Another alternative array arrangement is 9 solar panels approximately 2.7 metres x 0.9 metres in size with an array size of 8.1 metres x 2.7 metres.

Photo 1. Example of a typical solar array



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SITE LEGEND

- PROPOSED SOLAR ARRAY AREA STAGE 1
- PROPOSED SOLAR ARRAY AREA STAGE 2
- PROPOSED SOLAR FARM SUBSTATION LOCATION
- PROPOSED LANDSCAPING BUFFER
- VEGETATION AREA - CATEGORY A AND B AREA THAT IS A LEAST CONCERN REGIONAL ECOSYSTEM
- VEGETATION AREA - CATEGORY A AND B AREA CONTAINING OF CONCERN REGIONAL ECOSYSTEMS
- VEGETATION AREA - CATEGORY A AND B AREA CONTAINING ENDANGERED REGIONAL ECOSYSTEMS
- ACCESS TRACK LOCATIONS
- EXISTING RESIDENCES
- WATERWAY CORRIDORS

SOURCE: i³ CONSULTING PTY LTD

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PROJECT
CLERMONT SOLAR FARM

CLIENT
EPURON

ISSUE	DESCRIPTION	DATE
A	DRAFT	20/01/17
B	FINAL	09/02/17

SCALE
1:10000 @ A3

APPROVED BY
S CRAWFORD

NORTH

DRAWING NAME
GENERAL LAYOUT PLAN

DRAWING NUMBER
16006-FIGURE 6

ISSUE
B

4.2. Horizontal single axis tracking system

A horizontal single axis tracking system rotates the PV panels across an east to west arc, following the sun's trajectory across the sky. The purpose of the tracking system is to optimize solar energy collection by holding the PV module perpendicular to the sun. The tracking system is capable of a maximum rotation range of 90^o (+/- 45^o) or 120^o (+/- 60^o) depending on the system used. For the purpose of this study a rotation range of 120^o (+/- 60^o) has been used, refer *Figure 7.*

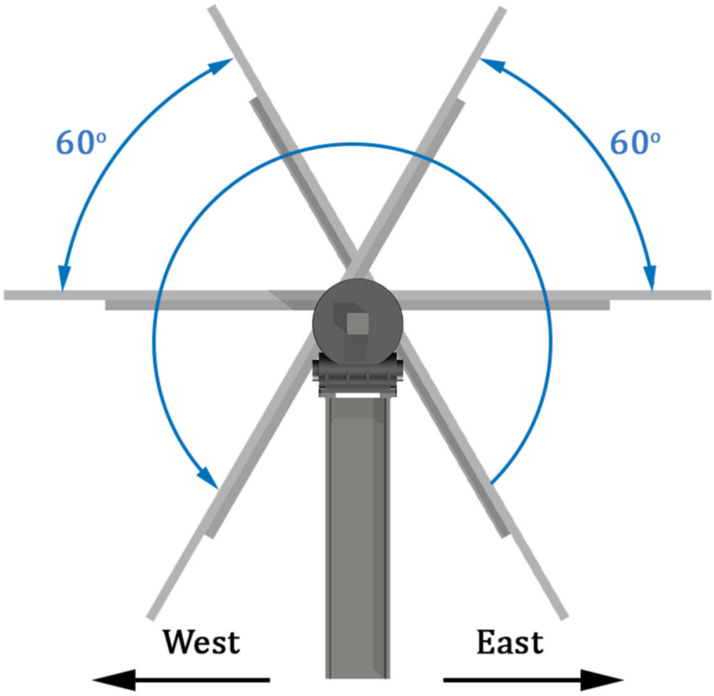


Figure 7. Illustration of PV Module Rotation Angles

The zenith tilt angle of the panels are assumed to be set at zero, that is, the panels are not tilted on a north – south alignment but remain horizontal along the plane of the tracker. This enables the height of the panel to remain consistent relative to each other and avoids potential over shadowing.

The maximum height of the PV modules above natural ground is approximately 2 to 3 metres, a height of 3 metres was used in the modelling.

This study has assumed the tracking system will utilise a 'backtracking' procedure to reduce the potential for over shadowing between panels.

The configuration of the tracking system rows may vary slightly dependent on the type of system used, in general the rows will be 3 to 7 metres apart. The PV modules are mounted in rows aligned north-south, refer *Figure 8.*

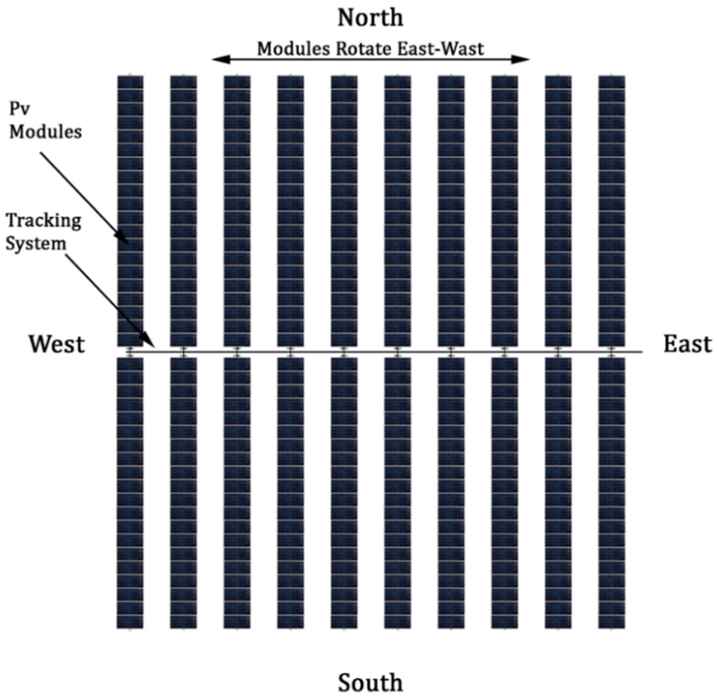


Figure 8. Illustration of PV Module Row Alignment for a horizontal single axis tracking system

4.3. Fixed tilt system

The study also assessed the potential glare impacts of a fixed tilt system in which the PV panels are supported by a frame at a fixed angle. The zenith tilt angle of the panels was set at 23 degrees, that is, the panels are tilted to the north at 23 degrees where 0 degrees is parallel to the ground. The panels were assumed to face true north. The maximum height of the PV modules above natural ground was set at 3 metres and therefore consistent across both type of system.

Photo 2. Example of a typical fixed tilt system

5. DESKTOP GLARE ASSESSMENT

The aim of the desktop glare assessment is to identify if any sensitive receptors have the potential to be impacted by glare. The software modelling systems used in the desktop assessment include viewshed modelling to identify the location of sensitive receptors with line of sight to the solar farm, and the SGHAT to identify the potential and ocular significance of glare.

5.1. Viewshed Analysis

The results of the viewshed analysis are shown in *Figure 9.*

The extent of visibility of the proposed solar farm is limited by existing topography and vegetation.

The results of the viewshed analysis are summarised below:

- Alpha Bypass Road is located within the viewshed on the northern boundary of the Project site.
- Clermont Alpha Road is located approximately 300 to 800 metres from the Project's northern boundary, intervening vegetation screens the project site from this road.
- Clermont Rubyvale Road is located outside the viewshed approximately 2.1 kilometres from the Project's eastern boundary.
- Rural dwelling at OP01, located 620 m to the north of the Project site, is the only rural property within the viewshed. The dwelling at OP01 is screened from the Project site by existing vegetation.

A conservative approach to the assessment of glare was undertaken based on screening by topography alone, that is, the model tested the potential for glare to occur from observations points without the screening effect provided by existing vegetation. The modelling was applied to 25 of the closest rural dwellings to the Project site and both the Alpha Bypass and Clermont Alpha roads.

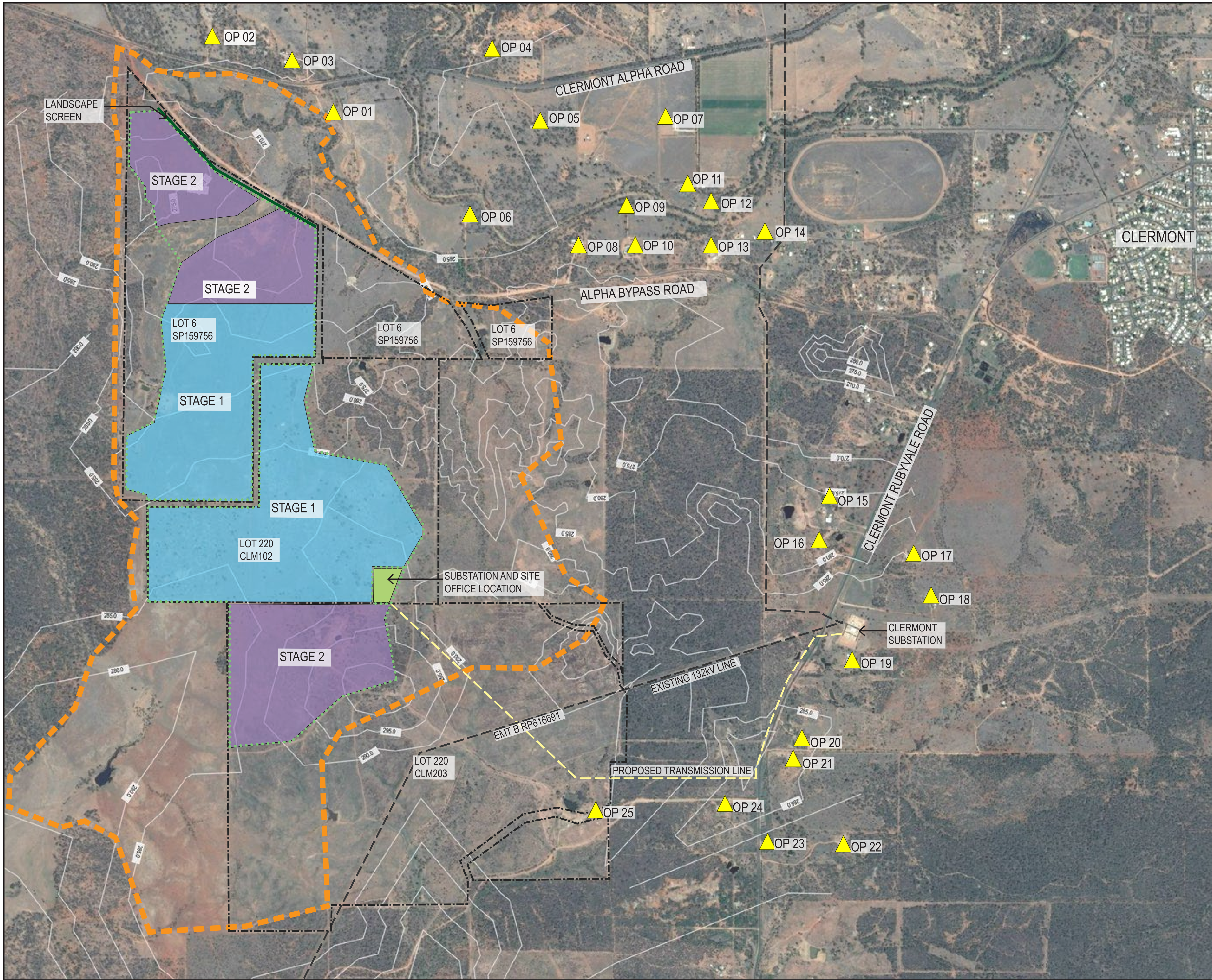
The results of the potential glare hazard impact for the 25 identified rural dwellings and surrounding roads has been assessed in *Section 5.2.*

5.2. Solar Glare Hazard Analysis - Horizontal Single Axis Tracking System

The parameters used in the SGHAT model for the horizontal single axis tracking system are detailed in *Table 1.*

Table 1. Input data for SGHAT Analysis – Horizontal Single Axis Tracking System

SGHAT Model Parameters	Values
Time Zone	UTC +10
Axis Tracking	Single
Tilt of tracking axis	0
Orientation of tracking axis	0
Offset angle of module	0
Module Surface material	Smooth glass without anti-reflective coating (ARC)
Maximum tracking angle	60



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LEGEND

- Proposed Solar Array Area Stage 1
- Proposed Solar Array Area Stage 2
- Proposed Substation
- Proposed Transmission line
- Contours (5m intervals)
- Lot boundaries
- Proposed fence
- Proposed landscape screen planting
- Observation Points (Rural Dwellings) within 2 km of the solar farm
- Extent of viewshed - approx. limit of visibility (screened by topography and vegetation)

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APPROVED BY
S CRAWFORD

NORTH

DRAWING NAME
VIEWSHED ANALYSIS

DRAWING NUMBER
16006-FIGURE 9

ISSUE
B

Height of panels above ground	3 m at rotational base

The assessment outcomes for the SGHAT model for the horizontal single axis tracking system are outlined in *Table 2:*

Table 2. SGHAT Assessment Results – Horizontal Single Axis Tracking System

Sensitive Receptor	Glare Potential
Observation Point 01- Rural Dwelling	No Glare
Observation Point 02 - Rural Dwelling	No Glare
Observation Point 03 - Rural Dwelling	No Glare
Observation Point 04 – Rural Dwelling	No Glare
Observation Point 05 - Rural Dwelling	No Glare
Observation Point 06 – Rural Dwelling	No Glare
Observation Point 07 - Rural Dwelling	No Glare
Observation Point 08 - Rural Dwelling	No Glare
Observation Point 09 - Rural Dwelling	No Glare
Observation Point 10 - Rural Dwelling	No Glare
Observation Point 11 - Rural Dwelling	No Glare
Observation Point 12 - Rural Dwelling	No Glare
Observation Point 13 - Rural Dwelling	No Glare
Observation Point 14 - Rural Dwelling	No Glare
Observation Point 15- Rural Dwelling	No Glare
Observation Point 16 - Rural Dwelling	No Glare
Observation Point 17 - Rural Dwelling	No Glare
Observation Point 18 – Rural Dwelling	No Glare
Observation Point 19 - Rural Dwelling	No Glare
Observation Point 20 – Rural Dwelling	No Glare
Observation Point 21 - Rural Dwelling	No Glare
Observation Point 22 - Rural Dwelling	No Glare
Observation Point 23 - Rural Dwelling	No Glare
Observation Point 24 - Rural Dwelling	No Glare
Observation Point 25 - Rural Dwelling	No Glare
Travel Path – Alpha Bypass Road	No Glare
Travel Path – Clermont Alpha Road	No Glare

5.3. Solar Glare Hazard Analysis – Fixed Tilt System

The parameters used in the SGHAT model for the fixed tilt system are detailed in *Table 3*

Table 3. Input data for SGHAT Analysis – Fixed Tilt System

SGHAT Model Parameters	Values
Time Zone	UTC +10

PV array axis tracking	None
Orientation of array (deg)	0,0
Tilt of solar panel (deg)	23,0
Vary reflectivity	True
Module Surface material	Smooth glass without anti-reflective coating (ARC)
Height of panels above ground	3 m

The assessment outcomes for the SGHAT model for the horizontal fixed tilt system are outlined in *Table 4:*

Table 4. SGHAT Assessment Results – Fixed Tilt System

Sensitive Receptor	Glare Potential
Observation Point 01- Rural Dwelling	Glare (Low potential for temporary after-image)
Observation Point 02 - Rural Dwelling	Glare (Potential for temporary after-image)
Observation Point 03 - Rural Dwelling	No Glare
Observation Point 04 – Rural Dwelling	Glare (Potential for temporary after-image)
Observation Point 05 - Rural Dwelling	Glare (Potential for temporary after-image)
Observation Point 06 – Rural Dwelling	Glare (Low potential for temporary after-image)
Observation Point 07 - Rural Dwelling	Glare (Low potential for temporary after-image)
Observation Point 08 - Rural Dwelling	Glare (Low potential for temporary after-image)
Observation Point 09 - Rural Dwelling	Glare (Low potential for temporary after-image)
Observation Point 10 - Rural Dwelling	Glare (Low potential for temporary after-image)
Observation Point 11 - Rural Dwelling	Glare (Low potential for temporary after-image)
Observation Point 12 - Rural Dwelling	Glare (Low potential for temporary after-image)
Observation Point 13 - Rural Dwelling	Glare (Potential for temporary after-image)
Observation Point 14 - Rural Dwelling	Glare (Low potential for temporary after-image)
Observation Point 15- Rural Dwelling	Glare (Potential for temporary after-image)
Observation Point 16 - Rural Dwelling	Glare (Potential for temporary after-image)
Observation Point 17 - Rural Dwelling	Glare (Potential for temporary after-image)
Observation Point 18 – Rural Dwelling	Glare (Potential for temporary after-image)
Observation Point 19 - Rural Dwelling	Glare (Potential for temporary after-image)
Observation Point 20 – Rural Dwelling	No Glare
Observation Point 21 - Rural Dwelling	No Glare
Observation Point 22 - Rural Dwelling	No Glare
Observation Point 23 - Rural Dwelling	No Glare
Observation Point 24 - Rural Dwelling	No Glare
Observation Point 25 - Rural Dwelling	No Glare
Travel Path – Alpha Bypass Road	Glare (Potential for temporary after-image)
Travel Path – Clermont Alpha Road	Glare (Potential for temporary after-image)

Further detail on the assessment outcomes for the SGHAT model for the fixed tilt system is provided in *Appendix A.*

5.4. Baseline conditions

The baseline condition within the vicinity of the Project site is characterised by flat to undulating agricultural land, predominately used for grazing. Surrounding lots include extensive areas of native vegetation and regrowth. Water courses are intermittent and there are a number of moderate sized dams in the surrounding area.

Existing dwellings in the area include homesteads to the north, south and east of the Project site, these are generally located in association with agricultural sheds. Clermont is the closest town to the Project, located approximately 6 km to the east of the Project site.

There are few existing features in the landscape with the potential to contribute to glare.

5.5. Atmospheric Conditions

Atmospheric conditions such as cloud cover, dust and haze will impact light reflection, however these factors have not been accounted for in this glare assessment. The Bureau of Meteorology statistics for Clermont Post Office (6 km east of the Project site) recorded 100.1 cloudy days per year (mean number over the period 1962 to 2010)[6]. Cloudy days predominately occur during the summer months, December to March. Since atmospheric conditions have not been factored into this assessment modelling, statistically the glare potential represents a conservative assessment.

6. ASSESSMENT RESULTS

The results of the SGHAT modelling identified no glare hazard potential is likely to be generated as a result of the operation of the Solar Farm where a horizontal single axis tracking system is installed. Currently SGHAT does not account for the ‘backtracking’ procedure, that is, variable angles of incidence of the sun relative to the PV module where the tracking system accounts for over shadowing potential. Therefore during the early morning and late afternoon when a backtracking procedure may be operating there may occur a variation to the angle of incidence of the sun relative to the PV modules compared to that predicted in this modelling. Existing vegetation along the east and western boundaries of the Project site is considered likely to mitigate potential glare should this occur during the backtracking procedure.

The SGHAT modelling found there is the potential for glare hazard to occur where a fixed tilt system is installed. SGHAT modelling identified potentially affected rural dwellings and travel paths located to the north, north-east, and east of the Project. The glare hazard potential generally occurs in the late afternoon during summer months, *refer Appendix A*. SGHAT modelling is based on topography and does not take into consideration existing vegetation. An assessment of glare hazard risk taking into consideration mitigation factors, such as existing and proposed screening vegetation, is outlined in *Table 5.*

[6] http://www.bom.gov.au/climate/averages/tables/cw_035019.shtml

Table 5. Glare potential risk assessment for fixed tilt system

Sensitive Receptor	Glare Potential (based on topography)	Mitigation factors	Risk
OP 01- Rural Dwelling	Glare (Low potential)	Existing vegetation screen	Negligible
OP 02 - Rural Dwelling	Glare (Potential)	Existing vegetation screen	Negligible
OP 03 - Rural Dwelling	No Glare		
OP 04 – Rural Dwelling	Glare (Potential)	Existing vegetation screen	Negligible
OP 05 - Rural Dwelling	Glare (Potential)	Existing vegetation screen	Negligible
OP 06 – Rural Dwelling	Glare (Low potential)	Existing vegetation screen	Negligible
OP 07 - Rural Dwelling	Glare (Low potential)	Existing vegetation screen	Negligible
OP 08 - Rural Dwelling	Glare (Low potential)	Existing vegetation screen	Negligible
OP 09 - Rural Dwelling	Glare (Low potential)	Existing vegetation screen	Negligible
OP 10 - Rural Dwelling	Glare (Low potential)	Existing vegetation screen	Negligible
OP 11 - Rural Dwelling	Glare (Low potential)	Existing vegetation screen	Negligible
OP 12 - Rural Dwelling	Glare (Low potential)	Existing vegetation screen	Negligible
OP 13 - Rural Dwelling	Glare (Potential)	Existing vegetation screen	Negligible
OP 14 - Rural Dwelling	Glare (Low potential)	Existing vegetation screen	Negligible
OP 15- Rural Dwelling	Glare (Potential)	Existing vegetation screen	Negligible
OP 16 - Rural Dwelling	Glare (Potential)	Existing vegetation screen	Negligible
OP 17 - Rural Dwelling	Glare (Potential)	Existing vegetation screen	Negligible
OP 18 – Rural Dwelling	Glare (Potential)	Existing vegetation screen	Negligible
OP 19 - Rural Dwelling	Glare (Potential)	Existing vegetation screen	Negligible
OP 20 – Rural Dwelling	No Glare		
OP 21 - Rural Dwelling	No Glare		
OP 22 - Rural Dwelling	No Glare		
OP 23 - Rural Dwelling	No Glare		
OP 24 - Rural Dwelling	No Glare		
OP 25 - Rural Dwelling	No Glare		
Alpha Bypass Road	Glare (Potential)	Proposed landscape screen	Negligible
Clermont Alpha Road	Glare (Potential)	Existing vegetation screen	Negligible

The viewshed modelling identified all rural dwellings and Clermont Alpha Road are screened from the Project site by existing vegetation, therefore this vegetation will screen potential glare.

Alpha Bypass Road located along the Project's northern boundary is currently not fully screened by existing vegetation and glare hazard potential was identified along this section of road. The proposed 3 to 5 metre high screen planting along the Project's northern boundary will significantly reduce the potential for glare to impact travellers. Establishment of the landscape screen prior to construction of Stage 2 on Lot 6 SP159756 should be undertaken in order to effect this mitigation factor.

This assessment took into consideration the operation of the Solar Farm during daylight hours throughout the year (SGHAT modelling calculates the potential for glare at 1 minute intervals).

SGHAT testing was undertaken for assumed sun energy intensity of 2000 W/m^2, which is 2x the US Federal Aviation Administration modelling requirement standards. In addition no allowance was made for atmospheric conditions.

In summary, based on the assumptions and parameters of this desktop assessment, the following results were identified:

- No glare potential was identified for surrounding dwellings, therefore the likely impact on these sensitive receptors within the viewshed was identified as insignificant;
- No glare potential was identified for Clermont Alpha Road, therefore the likely impact on motorists travelling in either direction along this road was identified as insignificant;
- Glare hazard potential was identified for travellers on Alpha Bypass Road where a fixed tilt system is installed, this potential is significantly reduced by the establishment of screen planting along the Project's northern boundary; and
- The landscape screen planting along Alpha Bypass Road should be established prior to construction of Stage 2 on Lot 6 SP159756 and maintained as a dense vegetation screen to the height indicated on the site layout plans in order to mitigate the potential for glare hazard along this section of road.

APPENDIX A:

SOLAR GLARE HAZARD ANALYSIS COMPILED REPORT

SOLAR GLARE HAZARD ANALYSIS REPORT

PV ARRAY VERTICES

ID	Latitude (deg)	Longitude (deg)	Ground Elevation (m)	Height of panels above ground (m)	Total elevation (m)
1	-22.82552	147.58424	275	3.0	278
2	-22.83225	147.58324	281	3.0	284
3	-22.83407	147.58253	282	3.0	285
4	-22.83739	147.58262	288	3.0	291
5	-22.8384	147.58613	291	3.0	294
6	-22.8422	147.58744	290	3.0	293
7	-22.8454	147.58574	295	3.0	298
8	-22.84917	147.58512	303	3.0	306
9	-22.85086	147.57613	288	3.0	291
10	-22.84406	147.57696	286	3.0	289
11	-22.84344	147.57243	288	3.0	291
12	-22.83828	147.57311	285	3.0	288
13	-22.83811	147.5719	287	3.0	290
14	-22.83397	147.57253	281	3.0	284
15	-22.83363	147.57365	280	3.0	283
16	-22.83007	147.574.7	279	3.0	282
17	-22.82266	147.57472	285	3.0	288
18	-22.81794	147.57541	272	3.0	275
19	-22.82188	147.57905	275	3.0	278
20	-22.82381	147.5815	267	3.0	270

OBSERVATION POINTS

ID	Latitude (deg)	Longitude (deg)	Ground Elevation (m)	Eye-level height above ground (m)
1	-22.81995	147.58585	270	1.5
2	-22.81552	147.57977	274	1.5
3	-22.81673	147.58373	271	1.5
4	-22.81797	147.59519	272	1.5
5	-22.82211	147.59729	269	1.5
6	-22.82623	147.59262	267	1.5
7	-22.82255	147.6041	264	1.5
8	-22.82815	147.59839	269	1.5
9	-22.8268	147.60127	266	1.5
10	-22.82889	147.60154	268	1.5
11	-22.82612	147.60481	266	1.5
12	-22.8271	147.60603	267	1.5
13	-22.82936	147.60579	269	1.5
14	-22.82909	147.60887	266	1.5
15	-22.84288	147.61046	278	1.5
16	-22.84514	147.60967	283	1.5
17	-22.84629	147.61471	290	1.5
18	-22.84845	147.61526	296	1.5
19	-22.85135	147.61049	289	1.5

20	-22.85504	147.60722	282	1.5
21	-22.85587	147.60652	283	1.5
22	-22.86064	147.60873	283	1.5
23	-22.86016	147.60455	280	1.5
24	-22.85796	147.601243	283	1.5
25	-22.85719	147.59559	287	1.5

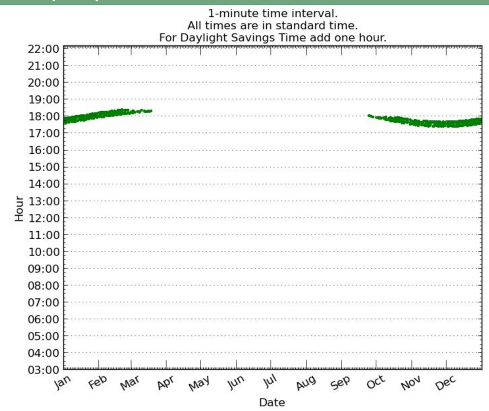
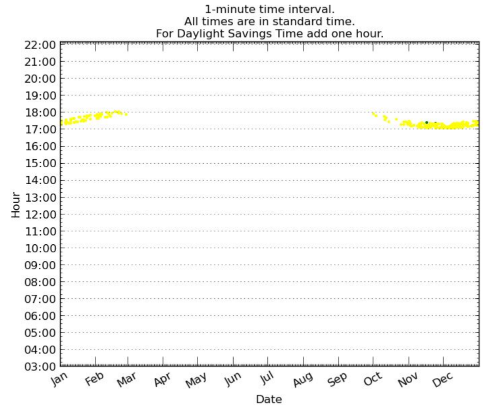
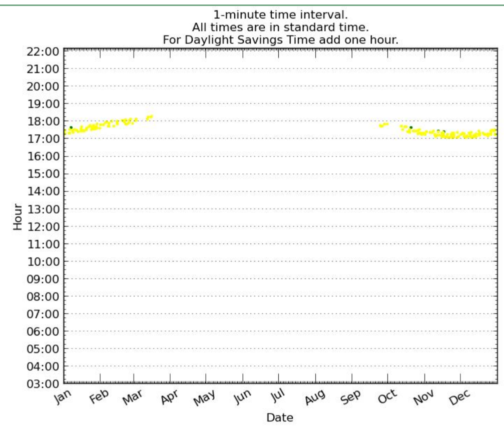
INPUTS – HORIZONTAL SINGLE AXIS TRACKING SYSTEM

Parameters	Inputs
PV array axis tracking	single
Tilt of tracking axis (deg)	0.0
Orientation of tracking axis (deg)	0.0
Offset angle of module (deg)	0.0
Limit rotation angle?	True
Maximum tracking angle (deg)	60.0
Vary reflectivity	True
PV surface material	Smooth glass without ARC
Timezone offset	+10.0
Subtended angle of sun (mrad)	9.3
Peak DNI (W/m^2)	2000.0
Ocular transmission coefficient	0.5
Pupil diameter (m)	0.002
Eye focal length (m)	0.017
Time interval (min)	1
Slope error (mrad)	10.0

INPUTS – FIXED TILT SYSTEM

Parameters	Inputs
PV array axis tracking	None
Tilt of solar panels (deg)	23,0
Orientation of array (deg)	0.0
Vary reflectivity	True
PV surface material	Smooth glass without ARC
Timezone offset	+10.0
Subtended angle of sun (mrad)	9.3
Peak DNI (W/m^2)	2000.0
Ocular transmission coefficient	0.5
Pupil diameter (m)	0.002
Eye focal length (m)	0.017
Time interval (min)	1
Slope error (mrad)	10.0

GLARE OCCURRENCE PLOTS – FIXED TILT SYSTEM

Location	Glare Potential	Output plots
Observation Point 01 - Rural Dwelling	Glare (Low potential for temporary after-image)	
Observation Point 02 - Rural Dwelling	Glare (Potential for temporary after-image)	
Observation Point 03 - Rural Dwelling	No Glare	
Observation Point 04 - Rural Dwelling	Glare (Potential for temporary after-image)	

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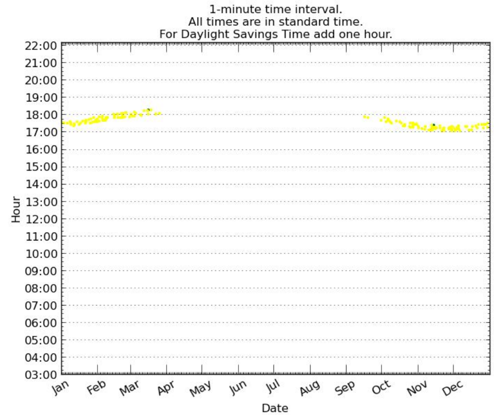
<tr><td>Observation Point 05 - Rural Dwelling</td><td>Glare (Potential for temporary after-image)</td><td>
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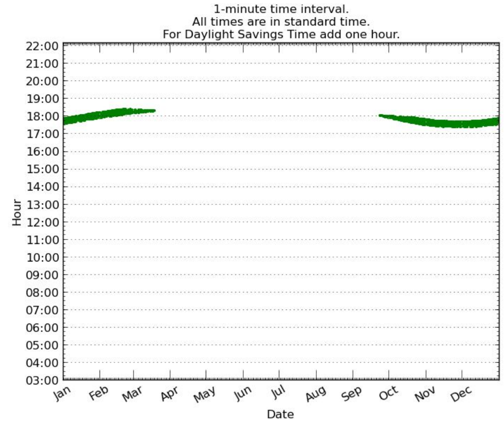
<tr><td>Observation Point 06 - Rural Dwelling</td><td>Glare (Low potential for temporary after-image)</td><td>
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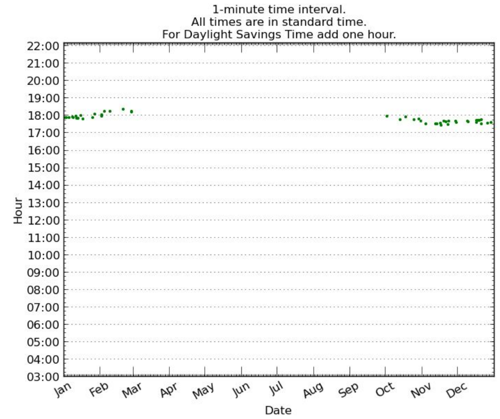
<tr><td>Observation Point 07 - Rural Dwelling</td><td>Glare (Low potential for temporary after-image)</td><td>
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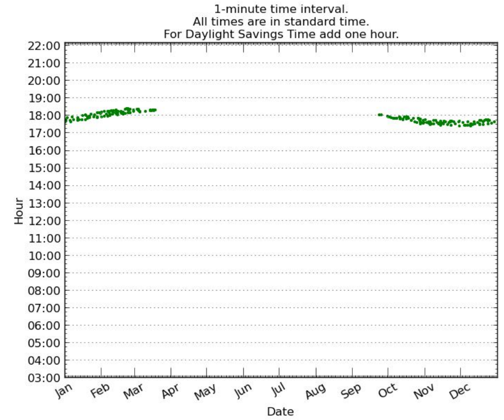
<tr><td>Observation Point 08 - Rural Dwelling</td><td>Glare (Low potential for temporary after-image)</td><td>
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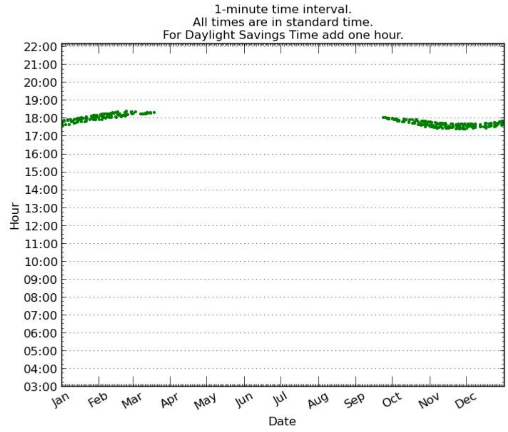
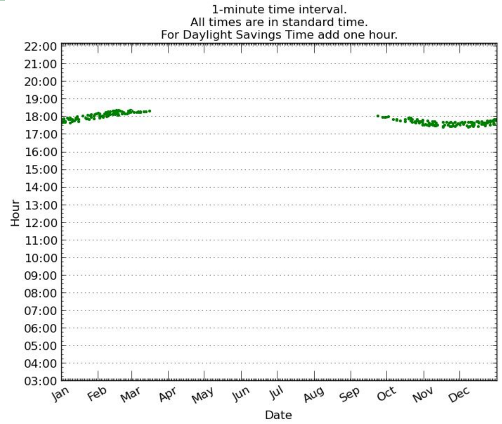
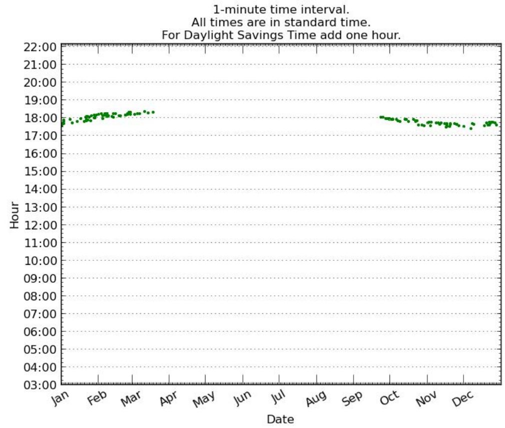
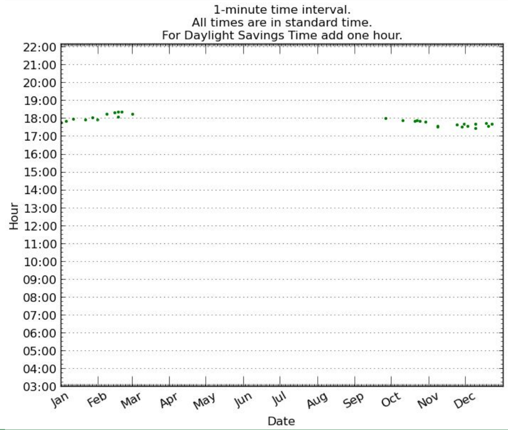
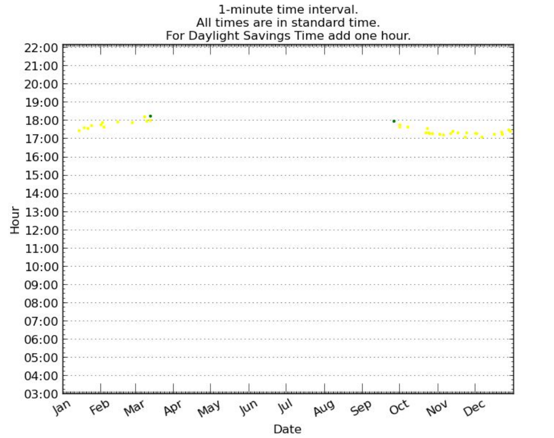
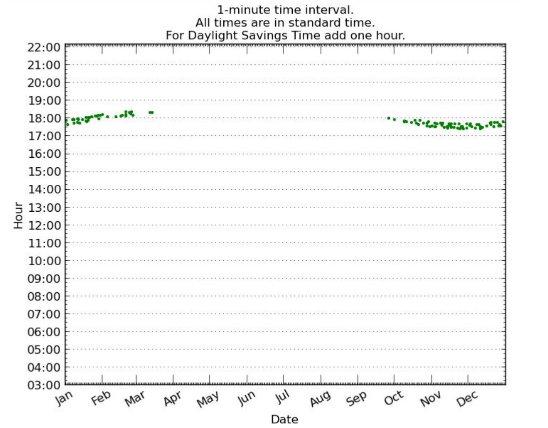
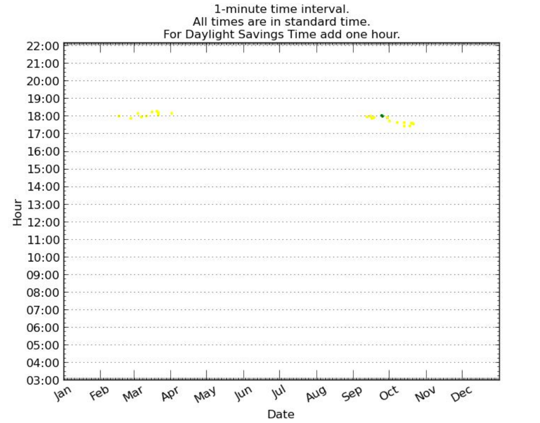
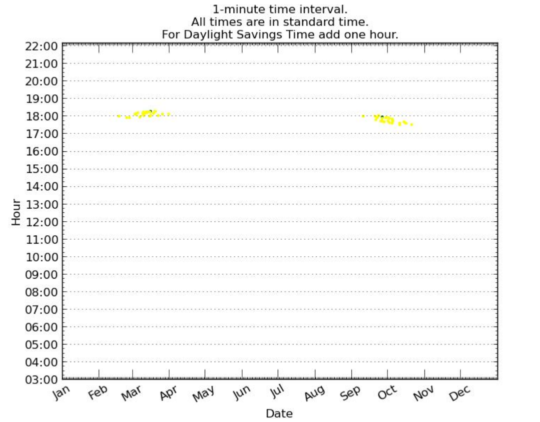
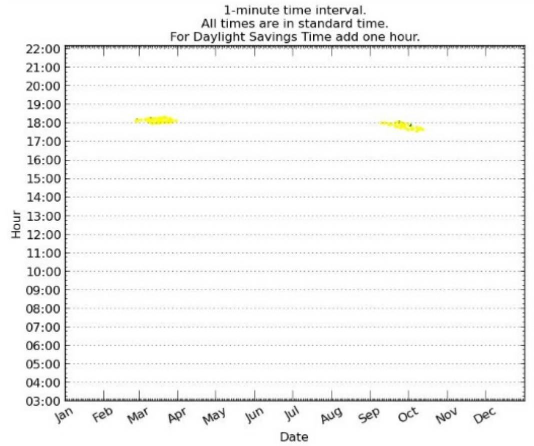
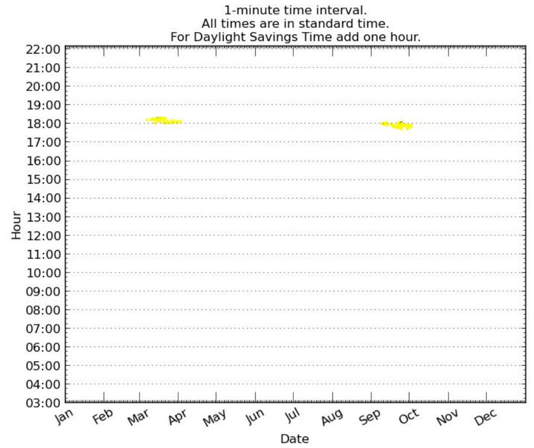
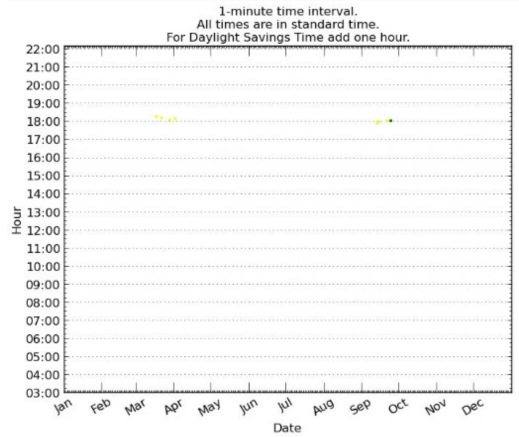
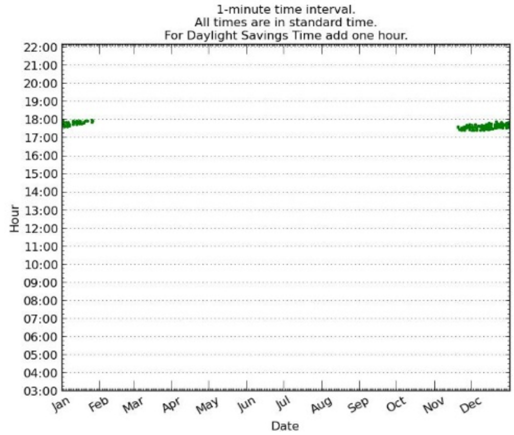
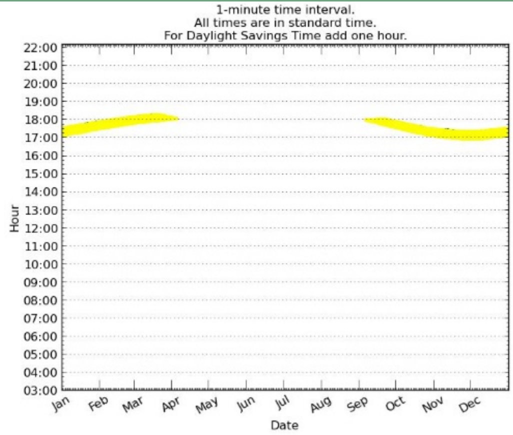
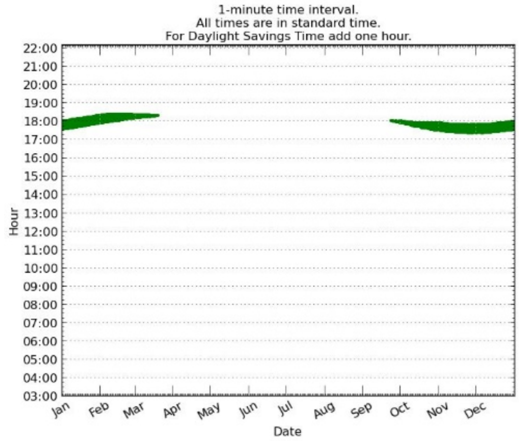
Observation Point 09 - Rural Dwelling	Glare (Low potential for temporary after-image)	
Observation Point 10 - Rural Dwelling	Glare (Low potential for temporary after-image)	
Observation Point 11 - Rural Dwelling	Glare (Low potential for temporary after-image)	
Observation Point 12 - Rural Dwelling	Glare (Low potential for temporary after-image)	

Observation Point 13 - Rural Dwelling	Glare (Potential for temporary after-image)	
Observation Point 14 - Rural Dwelling	Glare (Low potential for temporary after-image)	
Observation Point 15 - Rural Dwelling	Glare (Potential for temporary after-image)	
Observation Point 16 - Rural Dwelling	Glare (Potential for temporary after-image)	

Observation Point 17 - Rural Dwelling	Glare (Potential for temporary after-image)	
Observation Point 18 - Rural Dwelling	Glare (Potential for temporary after-image)	
Observation Point 19 - Rural Dwelling	Glare (Potential for temporary after-image)	
Observation Point 20 - Rural Dwelling	No Glare	
Observation Point 21 - Rural Dwelling	No Glare	
Observation Point 22 - Rural Dwelling	No Glare	
Observation Point 23 - Rural Dwelling	No Glare	
Observation Point 24 - Rural Dwelling	No Glare	

Observation Point 25 - Rural Dwelling	No Glare	
Alpha Bypass Road – OP01	No Glare	
Alpha Bypass Road – OP02	Glare (Low potential for temporary after-image)	
Alpha Bypass Road – OP03	Glare (Potential for temporary after-image)	
Alpha Bypass Road – OP04	Glare (Low potential for temporary after-image)	

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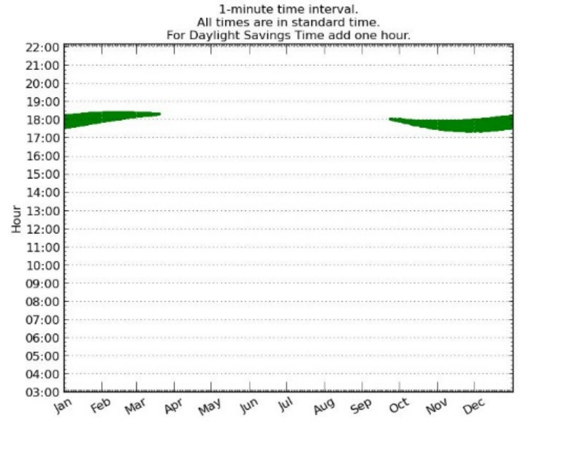
<tr><td>Alpha Bypass Road – OP05</td><td>Glare (Low potential for temporary after-image)</td><td>
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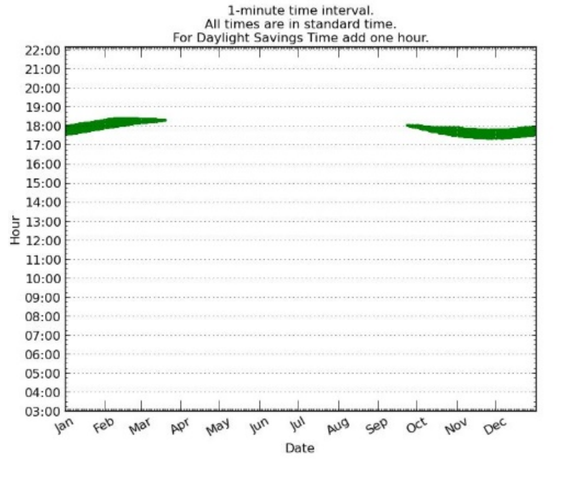
<tr><td>Alpha Bypass Road – OP06</td><td>Glare (Low potential for temporary after-image)</td><td>
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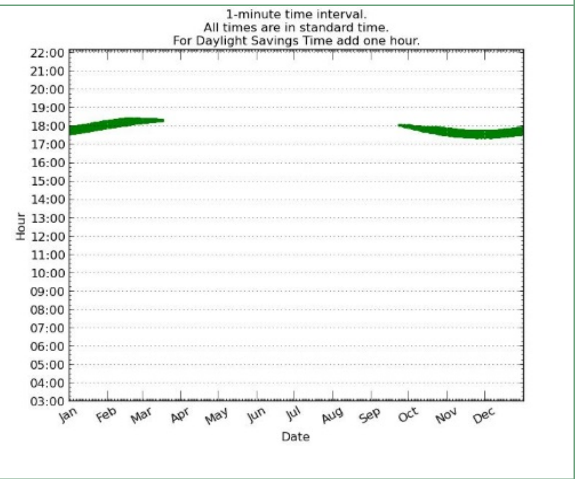
<tr><td>Alpha Bypass Road – OP07</td><td>Glare (Low potential for temporary after-image)</td><td>
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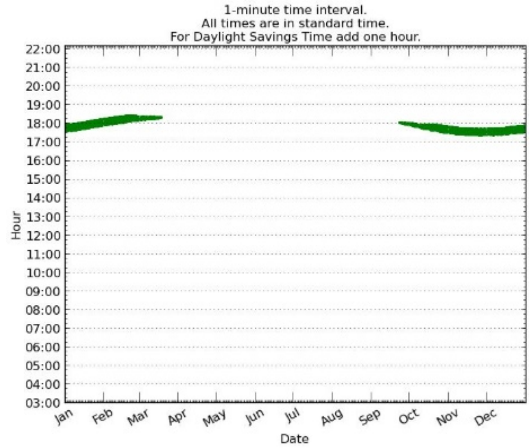
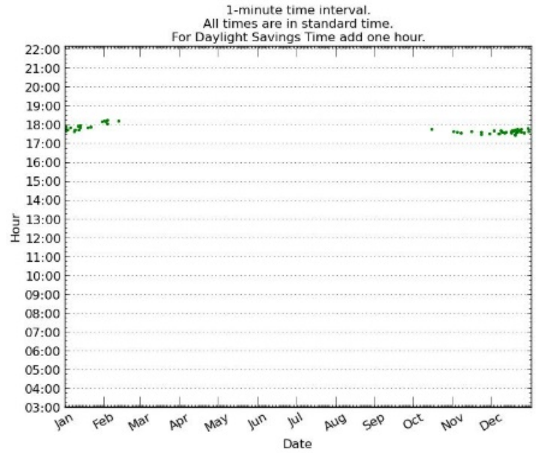
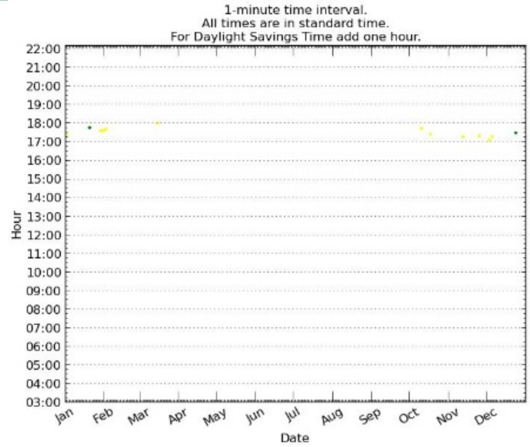
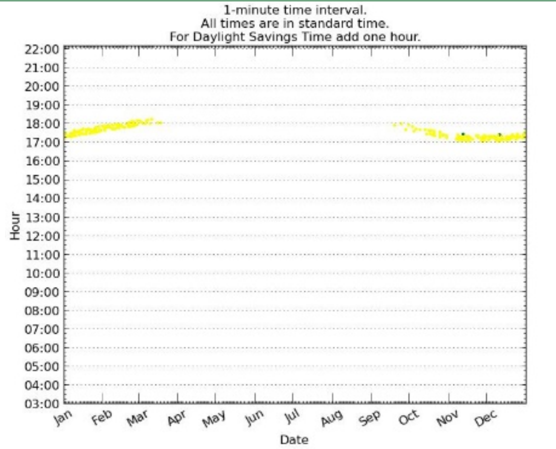
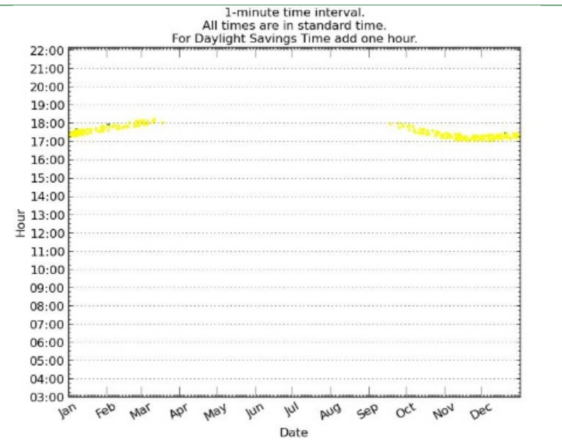
Alpha Bypass Road – OP08	Glare (Low potential for temporary after-image)	
Clermont Alpha Road - OP01	No Glare	
Clermont Alpha Road - OP02	No Glare	
Clermont Alpha Road - OP03	No Glare	
Clermont Alpha Road – OP04	Glare (Low potential for temporary after-image)	
Clermont Alpha Road – OP05	Glare (Low potential for temporary after-image)	

Clermont Alpha Road – OP06	Glare (Potential for temporary after-image)	
Clermont Alpha Road – OP07	Glare (Potential for temporary after-image)	
Clermont Alpha Road – OP08	Glare (Potential for temporary after-image)